DOCUMENT RESUME

ED 173 201 **SO 011 759**

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TITLE	Final Report for Dynamic Models for Causal Analysis of Panel Data. Preface.
INSTITUTION	Stanford Univ., Calif.
SPONS AGENCY	National Inst. of Education (DHEW), Washington, D.C.
PUB DATE	27 Dec 78
GRANT	NIE-G-76-0082
NOTE	8p.; For related documents, see SO 011 759-772
EDRS PRICE	MF01/PC01 Plus Postage.
DESCRIPTORS	Data Analysis; Data Collection; *Educational Change; Longitudinal Studies; Models; *Research Design; Research Methodology; Research Needs; Research Problems; *Research Projects; *Social Change; Social Science Research

ABSTRACT

This document introduces research aimed to explore methods that could be used to make inferences about causal effects of educational change over time when data are from an educational panel. This preface, the first in a series of 14 chapters described in SO 011 760-772, discusses an educational research project designed to examine affects of educational change and outlines the structure of the project's final report. First, activities of the research project are discussed. These include: integration and explications of models, methods, and results from existing relevant sociological, economic, and statistical literatures; extensions of these models, methods, and results to handle complications for which existing approaches were inadequate; investigation of the properties of different research designs and of different estimators; and performance of empirical analyses. A description of the project's final three-part report follows the discussion of project activities. Part I addresses broad issues of research design in the study of change. Two general arguments call for collecting data on the processes as well as the occurrence of change and shifting from the common discrete-time approach to continuous-time. Part II concerns analysis of data on quantitative (metric) outcomes. Analyses of common approaches and of issues involved in applying new strategies are discussed. Part III deals with dynamic analysis of qualitative outcomes such as remaining in school and kind of curriculum selected. Advantages of collecting event history data and problems in analyzing event-histories are examined. Effectiveness of Monte Carlo experiments, results of empirical analyses on the effects of schooling and ability on job changes, and research designs that minimize biases which result from ignoring interdependent systems of qualitative outcomes are discussed. (Author/KC)

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APR 5 1979

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Final Report for

DYNAMIC MODELS FOR CAUSAL ANALYSIS OF PANEL DATA. PREFACE.

National Institute of Education Research Grant #NIE-G-76-0082

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December 27, 1978

SP 011 759

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PREFACE

Our research aimed to explore methods that could be used to make inferences about causal effects of change over time when data are from an educational panel. We focused on continuous-time models because most phenomena studied in research pertaining to education can change at any moment (and not just at discrete intervals), even though over-time data are ordinarily collected periodically (and not continuously). Thus, an important problem in studying change is how best to use data from panels to make causal inferences about changes that may occur any time. We chose to do substantial work on both quantitative (metric or cardinal) outcomes and qualitative (categorical) outcomes. First, each type is prevalent in research related to education. More importantly, much educational research cries out for models with jointly-dependent quantitative and qualitative outcomes. Currently the lines between models and methods for the two kinds of outcomes are drawn rather sharply--much more sharply than is necessary or productive. Though a complete integration of methods for joint models of the two kinds of outcomes was beyond our immediate goals, we wished to cultivate the ground upon which the future development of such methodologies could be founded.

There are several aspects to our research activity: (1) integration and explication of models, methods and analytic results from existing literatures in education, sociology, economics and statistics that bear on our problem; (2) extension of these models, methods and results to handle various complications for which existing approaches were inadequate; (3) investigation of the properties of different research designs and of

different estimators by means of analytical work and Monte Carlo experiments; and (4) performance of some empirical analyses (using data related to education wherever feasible) to highlight the kinds of questions that might be addressed effectively using the various models and methods considered in the other aspects of our research activity.

The report has three parts. Part I addresses broad issues of research design in the study of change. We survey various designs typically employed by social scientists: panel designs, event-count, event-sequence, event-history and time series designs. We make two general arguments. First, much can be gained from collecting detailed data on the processes of change, e.g., on the timing of events as well as on the occurrence of a change. Social scientists and educational researchers seldom gather such complete data, even when it is feasible. Second, since most change processes of interest to educational researchers may occur any time, considerable analytic advantages result from using continuous-time models of change processes. We note that shifting from the common discrete-time approach to continuous-time modeling and using data on the timing of events greatly simplifies a number of serious methodological problems.

Part II concerns dynamic analysis of panel data on quantitative (metric) outcomes, e.g., academic achievement, earnings, etc. The first chapter in Part II gives a detailed analysis of the several common approaches to such analysis. It was prepared as a chapter in a monograph that reports analyses of the interrelations of educational expansion and national economic growth and modernization. Thus it focuses on applications to macro-analysis. In the second chapter in Part II, we illustrate the potential value of the explicit study of dynamics (in continuous-time)

for educational research. The analysis concerns the differences between growth and decline processes in the allocation of personnel in school districts. The allocation process is modelled as a system of coupled linear differential equations; model parameters are estimated from panel data (pooled cross-sections and time series) on school districts in California. We next turn our attention to analytic issues that must be addressed if the strategy we propose is to be applied to educational research. We have divided the discussion into three chapters. Chapter 3 of Part II addresses basic modeling issues from a deterministic perspective. It addresses the several interpretations of the parameters of linear differential equation models of the type used in the empirical analysis in Chapter 2 of Part II. It also discusses extensions to nonlinear models. Chapter 4 of Part II adds a probabilistic dimension by introducing stochastic differential equations. We discuss the formulation and interpretation of such equations and their possible value in social scientific research. Finally, in Chapter 5 of Part II we treat problems of estimating such dynamic models from panel data. We focus on the pervasive problem of autocorrelation of disturbances and advocate the use of pooled cross-section and time series designs to estimate some of the variance components that usually give rise to autocorrelation. We recommend the use of two estimators: a modified generalized least squares estimator and a maximum likelihood estimator. We close the chapter by comparing the behavior of the two estimators in a Monte Carlo study.

Part III deals with dynamic analysis of qualitative (categorical) outcomes, e.g., remaining in school or not, kind of curriculum selected, etc.

The first chapter in Part III outlines and illustrates dynamic analysis of categorical outcomes when retrospective information on dates of changes between the waves of a panel have been collected. The advantages of this sort of data, which we call event-history data, are compared to cross-sectional data, panel data, and data on counts of changes in a period. The second chapter in Part III considers different ways of dealing with a common problem in analyzing event histories--namely that the final wave of the panel occurs before an outcome has been recorded for all members of the sample. Results of Monte Carlo experiments reported in this chapter indicate that maximum likelihood (ML) estimators that explicitly deal with this problem have very good properties even in small samples and when many members of the sample have not yet had an outcome recorded. Partial likelihood (PL) estimators, which rest on weaker parametric assumptions than the ML estimators, are also reviewed. Chapters 3 through 5 reports results of a series of Monte Carlo experiments designed to study the properties of ML (and PL) estimators when various complications are introduced; these include causal effects with multicollinearity, omission of causal variables, time-dependence in parameters, and measurement error. On the whole we find that the maximum likelihood estimators have high quality (except in the case of an omitted variable correlated with an included variable); the quality of PL estimators is also very good. Chapters 6 and 7 of Part III reports results of empirical analyses on relative effects of schooling and ability on job changes. These chapters use extensions of the models and methods discussed in Chapters 1 through 5 of Part III. The analysis in Chapter 6 is based on a model in which the probability of job changing declines with

length of time in a job. Chapter 7 presents and uses a model in which unobservable variables as well as observables affect the probability of job changing. Chapter 8 of Part III focuses on coupled systems of qualitative outcomes and considers situations and research designs that minimize biases resulting from ignoring coupling (or interdependence).

Many people contributed to the research reported here. First, we especially wish to acknowledge our colleagues and students who coauthored some of the following chapters: Glenn Carroll (Chapters 4 and 5 of Part III), Mary Fennell (Chapter 3 of Part III), John Freeman (Chapter 2 of Part II), Lyle P. Groeneveld (Chapter 1 of Part III), Aage B. Sørensen (Chapter 6 of Part III), and Barbara Warsavage (Chapters 4 and 5 of Part III). We also wish to thank others who assisted in the research: Francois Nielsen, David Pasta and Marlos Viana. Burton Singer gave us valuable suggestions on several occasions and constructive comments on several chapters. Our secretary, Donna Mar, played a key role in keeping the project steaming ahead and also beautifully typed numerous reports and chapters (again and again).

Some of the chapters were supported in part by other grants and contracts, in particular, the National Institute of Mental Health (5-R01-MH29208-02) and the National Science Foundation (SOC78-12315). In addition, during one year of the grant Hannan was a Fellow at the Center for Advanced Study in the Behavioral Sciences and received support from the National Science Foundation (BNS76-22943). Contracts with the states of Washington and Colorado, prime contractors for the Department of Health, Education and Welfare under contract numbers SRS-70-53 and HEW-100-89-0004, respectively, supported part of the work on Chapter 1 of Part III.